August 30, 1996

To: Secretary, Room 222

Federal Communications Commission

1919 M Street, N.W.

Washington, DC 20554

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A PETITION FOR RECONSIDERATION

OF

FINAL RULE FCC 96-326

ET DOCKET NO. 93-62

regarding the new guidelines adopted by the FCC

to ensure that the public and workers receive adequate protection

from exposure to potentially harmful radio-frequency electromagnetic fields

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Under the Telecommunications Act of 1996 (TC Act) the Federal Communications Commission (FCC) has **sole** authority to establish health and safety regulations applicable to wireless communication devices. The electromagnetic fields (EMF) established in the space surrounding these devices as a result of their normal operation is the environmental agent of concern.

Normally, public health authorities are scattered among federal, state and municipal governments with sufficient overlap that a failure at one level can be compensated for at another level. Were this system still in place with respect to the EMF surrounding wireless devices, any action taken by the FCC for the purpose of protecting the health and safety of human beings exposed to such EMF would not be critical, because errors made by the FCC could be corrected at lower levels of government.

However, the TC Act stripped state and local governments of the authority they formerly enjoyed to enact such regulations to protect the health and safety of citizens within their jurisdiction. With these secondary and tertiary layers of protection shorn away, the FCC **alone** now bears the burden of protecting the public from the adverse health effects of exposure to wireless EMF.

It is therefore **critical** to the welfare of the United States of America (USA) that the FCC discharge this responsibility effectively! Should the FCC establish regulations that **seriously fail** to provide adequate health protection to all residents of the USA, the consequences to the country would be the same as though a hostile foreign power had infiltrated it without detection and released a disease-producing agent into the environment! In other words, it would be equivalent to a successful attack upon the country by an enemy agent bent upon destroying this country by poisoning our environment, so as to cause many people to sicken and die.

In 1864 James Clerk Maxwell publicly presented a paper titled "A Dynamical Theory of the Electromagnetic Field". This, and his subsequent *Treatise on Electricity and Magnetism*, laid the foundation for what is today called electromagnetic field theory (EMFT). A set of four equations—called "Maxwell's equations" in his honor—form the foundation of EMFT.

EMFT has been thoroughly tested over a period of many decades. It has been the foundation for several hugely successful enterprises over the past 150 years: in the 19th century, the telegraph and electric power generation and distribution; in the 20th century, a variety of wireless communications. Indeed, EMFT has been so widely accepted by everyone—scientists and non-scientists alike—that it may properly be regarded as a standard against which to measure the soundness of regulations whose purpose is to protect the public health from hazards that may be posed by the EMF sourrounding wireless communication devices.

In short, to assure that the health and safety regulations established by the FCC for wireless equipment are soundly based, it would be appropriate to require that these regulations be consistent with EMFT.

The regulations to protect human beings from hazardous effects of exposure to the EMF from wireless devices which were adopted by the FCC in Final Rule FCC 96-326 [published in the Federal Register, vol. 61, No. 153, 41006-41019] are **not fully consistent** with EMFT and therefore, in certain respects, **lack a sound scientific basis!** To the degree that this is true, they may be presumed to be inadequately protective of human health.

It is on the grounds of lack of a sound scientific basis, as exemplified by the inconsistency with EMFT, that this Petition for Reconsideration is based.

Electric and magnetic fields store energy. Work must be done to create an electric or a magnetic field. The energy expended is stored in the field, and is released when the field collapses.

When a collapsing electric or magnetic field releases its stored energy, this energy has to go somewhere. If there are electric charges present, these can be set in motion, producing an electric current; any remaining energy must be radiated away. (In a vacuum, where there are no electric charges present, *all* the energy released by the field collapse will be radiated away as electromagnetic energy.)

Poynting's theorem, which is taught to all undergraduate electric engineers, quantifies this energy balance. A derivation of it from two of Maxwell's equations is given in Appendix A. (In the text that follows below, vectors—which posses both magnitude and direction—are *underlined*. The *magnitude* of a vector is represented by its symbol *without* the underline.)

The *Poynting vector* $\underline{\mathcal{P}}$ represents an areal power density, also known as a power flux density—but most often referred to simply as *power density*; its units are watts/meter (or milliwatts/square centimeter). The Poynting vector is defined in terms of the electric and magnetic field vectors:

$$\underline{\mathcal{P}} \equiv \underline{E} \times \underline{H}.$$

In terms of the Poynting vector, Poynting's theorem may be written as follows (where σ is a current density) for a simple medium:

$$- \partial/\partial t \; \{ \tfrac{1}{2} \int_V (\underline{D} \bullet \underline{E} + \underline{B} \bullet \underline{H}) dv \} = \int_V \sigma E^2 \, dv + \oint_S \underline{\mathcal{P}} \bullet d\underline{s}$$

where the left side of the equation expresses the rate at which energy is released by collapsing electric and magnetic fields (the negative sign signifies release of energy). The first term on the right represents the rate of heat generation due to current flow: ohmic heat. The second term on the right represents the rate at which electromagnetic energy flows out through the boundary of the volume of interest. The whole equation is therefore an energy balance equation, expressing in a mathematically precise manner the same idea expressed in words two paragraphs previously.

A slightly different interpretation can be given by rewriting this equation as follows:

$$- \oint_S \underline{\mathcal{P}} \bullet d\underline{s} = \int_V \sigma E^2 \, dv + \partial/\partial t \{ \tfrac{1}{2} \int_V (\underline{D} \bullet \underline{E} + \underline{B} \bullet \underline{H}) \} dv.$$

This form is useful if we imagine that electromagnetic radiation is impinging upon a material body which occupies a volume V bounded by a surface S. The term on the left side, being negative, represents a net rate of energy flow across the surface *into* the volume: the rate at which energy is delivered to the material body. What happens to this energy? Some is absorbed, being transformed to heat; this is represented by the first term on the right side. The remainder is stored in the material body by the establishment in this body of electric and magnetic fields.

This idea is the concept upon which the very first voluntary consensus standard—ANSI/IEEE C95.1-1966—was based. Replace the material body in the paragraph above by a living being, and imagine that electromagnetic radiation is impinging upon it. What would be a worst-case scenario?

Only thermal hazards to health, which result from heating, were recognized in the USA in the mid-20th century. The worst case, then, would be when *all* the energy of the electromagnetic radiation is absorbed and transformed to heat!

In the simple case of a plane electromagnetic wave, the rate of energy delivery to the body is the product of the magnitude of the Poynting vector and the cross-sectional area of the body perpendicular to the incoming radiation:

$$\textit{rate of heating of body} = \mathcal{P} \, S_X$$

and the challenge for the early ANSI C95 Committee was to determine how high a rate of heating a human being or a mammal could tolerate without permanent damage to health; that is, what the upper limit should be for the left side of this equation.

However, this depends on the heat capacity of the material of which the body is made. In order to impose a limit on a feature of the electromagnetic field alone, this equation can be rewritten to produce an upper limit on the magnitude of the Poynting vector, in terms of what is tolerable for a living organism:

$$\textit{upper limit on } \mathcal{P} = (\textit{maximum acceptable rate of heating of body})/S_X$$

This is how it came to pass that the first voluntary consensus standard in the USA imposed an upper limit on the magnitude of the Poynting vector of the electromagnetic field.

There is no instrument that measures $\mathcal{P}$ directly; instead, measurements are made of the strength of the electric and magnetic fields. In some parts of the frequency spectrum, the standard is expressed in terms of upper limits on the electric and magnetic field strengths, instead of a power density. But the objective of the standard has always been to limit the magnitude of the Poynting vector of the electromagnetic field.

This has worked well, over the past 30 years, in terms of its original objective: to prevent damage to health by overheating of biological tissues. This is the only thing the original standard was designed to accomplish, as nonthermal hazards to health were not taken seriously at that time.

But the ANSI C95 Committee has made an error, which is now having very serious consequences: it declared that this standard applies ***everywhere!*** This is not true. The original concept was based on a simple model: a plane electromagnetic wave impinging upon a body. This model is valid *only in the far field* of a radiation source.

But when one is close enough to a source of radiation to be in the near or intermediate field of a transmitter, the electromagnetic field is no longer a plane wave, and the direction of the Poynting vector no longer remains constant. It is necessary to return to Poynting's theorem to find an equation that is valid *everywhere* in space.

Using the divergence theorem to transform the surface integral to a volume integral, and then equating integrands because the volume of integration is arbitrary, we obtain a simple form of Poynting's theorem, equivalent to equation 8-80 in Appendix A:

$$\sigma E^2 = \underline{E} \bullet \underline{J} = - [\nabla \bullet \underline{\mathcal{P}} + \underline{E} \bullet \partial \underline{D}/\partial t + \underline{H} \bullet \partial \underline{B}/\partial t].$$

The left side of this equation represents the heat generated at a given time and place. But we no longer have an equation that is proportional to the magnitude of the Poynting vector!

It is not difficult to show that, for a plane electromagnetic wave—that is, in the radiation field—the divergence of the Poynting vector is proportional to the magnitude of the Poynting vector: $\nabla \bullet \underline{\mathcal{P}} \propto \mathcal{P}$. But this is ***not true*** in the much more complex electromagnetic fields characteristic of the ***intermediate*** and ***near fields*** of a transmitter, where the radiation term is either small or comparable in magnitude to the other terms in the field equations. For the intermediate and near fields of a transmitter, the scientifically valid equation is the one above, involving the divergence of the Poynting vector, as well as additional terms in the electric and magnetic fields, and their time derivatives.

Thus there is ***no scientific basis*** for applying the exposure limits of ANSI/IEEE C95.1, which impose an upper limit on the magnitude of the Poynting vector, ***outside the far field*** of a radiation source. Assertions to the contrary made within this standard are erroneous.

All documents for the last thirty years seem to have accepted that the limits in ANSI/ IEEE C95.1 represent a universal truth, and all evaluations have been carried out accordingly. Thus every other document purporting to be an independent evaluation of the available evidence with respect to the safety of non-ionizing EMF must be critically examined for contamination by the ANSI/IEEE error! I am not aware of any that are uncontaminated.

This means that the already-issued FCC regulations applicable sufficiently close to transmitters to be outside the far (radiation) field of the transmitter ***lack a sound scientific foundation***. The FCC regulations applying to the far field seem to be scientifically sound, insofar as they rely upon established standards and are meant to control only thermal health effects—which brings me to a second point.

There are two kinds of health effect associated with exposure to a non-ionizing electromagnetic field: thermal and nonthermal effects. The existence of nonthermal health effects has been controversial, but the scientific consensus is swinging in favor of their existence. Appendix B discusses the matter at some length.

To summarize, then, the FCC ideally requires the existence of four different standards before it begins the task of consolidating them so as to establish a single standard for the far field, and another standard for the near/intermediate field of a radio-frequency transmitter:

- *for thermal effects*, a standard in the near/intermediate field, and one in the far field*
- *for nonthermal effects*, a standard in the near/intermediate field, and one in the far field.

Only one of these—the one starred above—currently exists. We have gotten along without any obvious need for a nonthermal effects standard in the far field, up to now. One certainly ought to be developed, but the need for it does not appear to be urgent.

There ***is*** an urgent need for some kind of regulatory action by the FCC with respect to the ***near field*** of radio-frequency sources, as there is growing evidence of cancer associated with human exposure to these fields—and possibly to intermediate fields, as well. [Other health effects, such as hypersensitivity to electromagnetic fields (also termed electrosensitivity) seem to be a growing problem—at least, in certain environments.]

The public health problem, and the kind of action needed at present to protect the public, is discussed in Appendix C.

I recommend that the FCC hold a public hearing on this issue of EMF health standards. The health standards that the FCC has promulgated fall so far short of what is needed to provide ***genuine*** protection to human health, that the shortcomings need to be made public in a very visible way, if only so that the public can begin to take steps to protect itself immediately, before the FCC makes its final decision. A public hearing will provide this opportunity.

The document in Appendix C provides my best recommendations as a bioelectromagnetic hygienist—a specialized professional in the field of environmental disease prevention—at the time it was written. I am revising that document, even now, to provide more information. But my recommendation—to establish a "forbidden zone" around each transmitter that includes the near field and most of the intermediate field—will certainly arouse controversy, and ought to be discussed in a public forum.

Affadavit

I declare under penalty of perjury that the foregoing is true and correct.

August 30, 1996 Marjorie Lundquist
(date) (signed) Marjorie Lundquist

Attachments: Appendices A, B and C

APPENDIX A

DERIVATION OF POYNTING'S THEOREM

Source:

Field and Wave Electromagnetics, 2nd ed.

David K. Cheng

Addison-Wesley Publishing Company, Inc., 1989; pages 379-381.

(This is a textbook used in undergraduate electrical engineering courses.)

8–5 Flow of Electromagnetic Power and the Poynting Vector

Electromagnetic waves carry with them electromagnetic power. Energy is transported through space to distant receiving points by electromagnetic waves. We will now derive a relation between the rate of such energy transfer and the electric and magnetic field intensities associated with a traveling electromagnetic wave.

We begin with the curl equations:

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \qquad \text{(7–53a)} \quad \text{(8–77)}$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}. \qquad \text{(7–53b)} \quad \text{(8–78)}$$

The verification of the following identity of vector operations (see Problem P.2–33) is straightforward:

$$\nabla \cdot (\mathbf{E} \times \mathbf{H}) = \mathbf{H} \cdot (\nabla \times \mathbf{E}) - \mathbf{E} \cdot (\nabla \times \mathbf{H}). \tag{8-79}$$

Substitution of Eqs. (8–77) and (8–78) in Eq. (8–79) yields

$$\nabla \cdot (\mathbf{E} \times \mathbf{H}) = -\mathbf{H} \cdot \frac{\partial \mathbf{B}}{\partial t} - \mathbf{E} \cdot \frac{\partial \mathbf{D}}{\partial t} - \mathbf{E} \cdot \mathbf{J}. \tag{8-80}$$

In a simple medium, whose constitutive parameters ϵ, μ, and σ do not change with time, we have

$$\mathbf{H} \cdot \frac{\partial \mathbf{B}}{\partial t} = \mathbf{H} \cdot \frac{\partial(\mu \mathbf{H})}{\partial t} = \frac{1}{2} \frac{\partial(\mu \mathbf{H} \cdot \mathbf{H})}{\partial t} = \frac{\partial}{\partial t}\left(\frac{1}{2} \mu H^2\right),$$

$$\mathbf{E} \cdot \frac{\partial \mathbf{D}}{\partial t} = \mathbf{E} \cdot \frac{\partial(\epsilon \mathbf{E})}{\partial t} = \frac{1}{2} \frac{\partial(\epsilon \mathbf{E} \cdot \mathbf{E})}{\partial t} = \frac{\partial}{\partial t}\left(\frac{1}{2} \epsilon E^2\right),$$

$$\mathbf{E} \cdot \mathbf{J} = \mathbf{E} \cdot (\sigma \mathbf{E}) = \sigma E^2.$$

Equation (8–80) can then be written as

$$\nabla \cdot (\mathbf{E} \times \mathbf{H}) = -\frac{\partial}{\partial t}\left(\frac{1}{2} \epsilon E^2 + \frac{1}{2} \mu H^2\right) - \sigma E^2, \tag{8-81}$$

which is a point-function relationship. An integral form of Eq. (8–81) is obtained by integrating both sides over the volume of concern:

$$\oint_S (\mathbf{E} \times \mathbf{H}) \cdot d\mathbf{s} = -\frac{\partial}{\partial t} \int_V \left(\frac{1}{2} \epsilon E^2 + \frac{1}{2} \mu H^2\right) dv - \int_V \sigma E^2 \, dv, \tag{8-82}$$

where the divergence theorem has been applied to convert the volume integral of $\nabla \cdot (\mathbf{E} \times \mathbf{H})$ to the closed surface integral of $(\mathbf{E} \times \mathbf{H})$.

We recognize that the first and second terms on the right side of Eq. (8–82) represent the time-rate of change of the energy stored in the electric and magnetic fields, respectively. [Compare with Eqs. (3–176b) and (6–172c).] The last term is the ohmic power dissipated in the volume as a result of the flow of conduction current density $\sigma\mathbf{E}$ in the presence of the electric field $\mathbf{E}$. Hence we may interpret the right side of Eq. (8–82) as the *rate of decrease* of the electric and magnetic energies stored, subtracted by the ohmic power dissipated as heat in the volume V. To be consistent with the law of conservation of energy, this must equal the power (rate of energy) *leaving* the volume through its surface. Thus the quantity $(\mathbf{E} \times \mathbf{H})$ is a vector representing the power flow per unit area. Define

$$\boxed{\mathscr{P} = \mathbf{E} \times \mathbf{H} \qquad (\mathrm{W/m^2}).} \tag{8-83}$$

Quantity $\mathscr{P}$ is known as the ***Poynting vector***, which is a power density vector associated with an electromagnetic field. The assertion that the surface integral of $\mathscr{P}$ over a closed surface, as given by the left side of Eq. (8–82), equals the power leaving the enclosed volume is referred to as ***Poynting's theorem***. This assertion is not limited to plane waves.

Equation (8-82) may be written in another form:

$$-\oint_S \mathscr{P} \cdot d\mathbf{s} = \frac{\partial}{\partial t}\int_V (w_e + w_m)\,dv + \int_V p_\sigma\,dv, \tag{8-84}$$

where

$$w_e = \tfrac{1}{2}\epsilon E^2 = \tfrac{1}{2}\epsilon \mathbf{E}\cdot\mathbf{E}^* = \text{Electric energy density}, \tag{8-85}$$

$$w_m = \tfrac{1}{2}\mu H^2 = \tfrac{1}{2}\mu \mathbf{H}\cdot\mathbf{H}^* = \text{Magnetic energy density}, \tag{8-86}$$

$$p_\sigma = \sigma E^2 = J^2/\sigma = \sigma\mathbf{E}\cdot\mathbf{E}^* = \mathbf{J}\cdot\mathbf{J}^*/\sigma = \text{Ohmic power density}. \tag{8-87}$$

In words, Eq. (8-84) states that the total power flowing *into* a closed surface at any instant equals the sum of the rates of increase of the stored electric and magnetic energies and the ohmic power dissipated within the enclosed volume.

Two points concerning the Poynting vector are worthy of note. First, the power relations given in Eqs. (8-82) and (8-84) pertain to the total power flow across a closed surface obtained by the surface integral of ($\mathbf{E} \times \mathbf{H}$). The definition of the Poynting vector in Eq. (8-83) as the power density vector at *every point* on the surface is an *arbitrary*, albeit useful, *concept*. Second, the Poynting vector $\mathscr{P}$ is in a direction normal to both $\mathbf{E}$ and $\mathbf{H}$.

If the region of concern is lossless ($\sigma = 0$), then the last term in Eq. (8-84) vanishes, and the total power flowing into a closed surface is equal to the rate of increase of the stored electric and magnetic energies in the enclosed volume. In a static situation, the first two terms on the right side of Eq. (8-84) vanish, and the total power flowing into a closed surface is equal to the ohmic power dissipated in the enclosed volume.

EXAMPLE 8-7 Find the Poynting vector on the surface of a long, straight conducting wire (of radius b and conductivity σ) that carries a direct current I. Verify Poynting's theorem.

Solution Since we have a d-c situation, the current in the wire is uniformly distributed over its cross-sectional area. Let us assume that the axis of the wire coincides with the z-axis. Figure 8-8 shows a segment of length ℓ of the long wire. We have

$$\mathbf{J} = \mathbf{a}_z \frac{I}{\pi b^2}$$

and

$$\mathbf{E} = \frac{\mathbf{J}}{\sigma} = \mathbf{a}_z \frac{I}{\sigma\pi b^2}.$$

On the surface of the wire,

$$\mathbf{H} = \mathbf{a}_\phi \frac{I}{2\pi b}.$$

APPENDIX B

INADEQUACY OF EXISTING STANDARDS
FOR EXPOSURE TO NON-IONIZING EMF
WITH RESPECT TO
CANCER AND OTHER NONTHERMAL HEALTH HAZARDS

On the following pages is the first draft of a letter written in response to the publication of a document purporting to offer protective human exposure standards applicable to hand-held radiotelephones, of the type used in cellular telephone systems and personal communications systems. This letter critcizes the evaluation made in the document, which is typical of that generally employed in the standard-setting process.

This draft letter, which will eventually be published in some modified form, is included here because it explains why the health concerns of the public are being inadequately addressed by existing standards for human exposure to radio-frequency radiation. In particular, it explains why existing standards are irrelevant to a cancer hazard.

IRRELEVANCE OF THE ICNIRP STATEMENT ON HAND-HELD RADIOTELEPHONES TO ANY BRAIN CANCER HAZARD POSED BY THE USE OF CELLULAR TELEPHONES

Dear Editors:

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) recently issued a statement (ICNIRP 1996) addressing health issues associated with the use of hand-held radiotelephones, brain cancer being mentioned as a particular concern. The cases of brain cancer that have been reported among users of cellular telephones are believed by the public to be the result of exposure to the electromagnetic field in the vicinity of these devices during use. The ICNIRP statement recommends a standard limiting non-ionizing electromagnetic radiation exposure, the basis for this standard being a specific absorption rate (SAR).

Presumably the reason for the exposure limit recommended in the ICNIRP statement is to reduce any risk of brain cancer to people using hand-held radiotelephones. This is strongly implied by the fourth conclusion in the ICNIRP statement: "There is no substantive evidence that adverse health effects, including cancer, can occur in people exposed to levels at or below the limits . . . recommended by INIRC (IRPA/INIRC 1988) . . ."

Like the members of the ICNIRP, I too have been concerned about the brain cancer hazard that cellular telephones may pose to their users. Like the ICNIRP, I also have published—quite independently—a document (Lundquist 1996) that offers the public advice about how to prevent the brain cancer risk that may be associated with the use of these devices.

Therefore it was with great interest that I began reading the ICNIRP statement, the text of which was published in the April, 1996, issue of *Health Physics*. As I read it, however, my interest turned to alarm! The ICNIRP statement gives the reader the impression that following its recommendations can be expected to provide some measure of protection against any brain cancer hazard to which the users of cellular telephones may be exposed. In my professional judgment, there is *no scientific basis at all* to support such a conclusion!

When an individual challenges the carefully considered statement of a prestigious international commission, the qualifications and credentials of the challenger are naturally of interest. Mine are two earned graduate degrees in physics—the M.S. and Ph.D.—conferred by the University of Virginia in the early 1960s, and certification in the comprehensive practice of industrial hygiene by the American Board of Industrial Hygiene. This latter entitles me to place the letters "C.I.H." after my name.

Industrial hygiene, like health physics, is a profession of disease prevention. Industrial hygiene arose in the United States as a result of a survey of Illinois factories undertaken by Alice Hamilton, M.D., in 1911 at the request of the governor of Illinois (Hamilton, 1943). Two professional societies were founded in the late 1930s: the American Conference of Governmental Industrial Hygienists (ACGIH), and the American Industrial Hygiene Association (AIHA). Membership in the ACGIH was restricted to people who worked for government agencies or in academia, and who could therefore be presumed to be motivated entirely by considerations of the public welfare in the course of their professional activities. Membership in the AIHA was open to people working in industry, as well.

Industrial hygiene is a profession devoted to the prevention of those diseases that result from exposure to harmful agents in the environment. *Any* environmental agent, exposure to which may have harmful consequences, is a concern of the industrial hygienist—though in its early history, the profession was primarily concerned with chemical agents. In recent years physical and biological agents have become increasingly important to the industrial hygiene community, making this profession one which addresses *all* aspects of the environment that can produce illness.

Thus I am a Board-certified professional in a field of environmental disease prevention, with graduate degrees in a discipline—physics—that is pertinent to the agent of interest here: electromagnetic fields. So far as I can discover, not one of the 15 authors of the ICNIRP statement possesses credentials as appropriate to the purpose of that document as mine! I have studied the scientific literature on the health effects of electromagnetic fields in depth and comprehensively for most of a decade, and have studied electromagnetic field theory thoroughly, as well. Because of this study and my credentials, I believe I am exceedingly well qualified to evaluate the ICNIRP statement.

In this letter I shall show that there is *no scientific basis* to justify the belief of members of the ICNIRP that an SAR-based exposure standard can provide protection against a cancer hazard arising from exposure to non-ionizing electromagnetic fields. This means that the ICNIRP statement, by implying that the SAR-based exposure limits it recommends *can* be expected to reduce any risk of brain cancer associated with the use of hand-held radiotelephones, is *deceiving the public!*

Before I proceed with specific criticism of the ICNIRP statement, I should emphasize that I applaud the concern about a possible cancer hazard from the use of hand-held radiotelephones that motivated the preparation and issuance of the ICNIRP statement. Unlike the ICNIRP, which appears to be uncertain whether a brain cancer hazard attributable to the use of these devices actually exists, I am confident not only that this hazard is real, but also that when the duration of exposure is sufficiently prolonged, the risk of brain cancer to the users of hand-held radiotelephones is *alarmingly high!* Because of the current widespread use of self-contained hand-held cellular telephones within the USA, I consider that this country at present is in the very early stages of what could easily become a massive epidemic of brain cancer among the millions of users of cellular telephones, if the use of these convenient, highly portable devices is not drastically curtailed in the very near future!

Notice that I do not condemn the *entire* ICNIRP statement. My criticism is reserved for the exposure limits recommended in the third, seventh and eighth conclusions of this document, insofar as they are likely to be interpreted as effecting a reduction in the risk of brain cancer. It is my professional judgment that *none* of the exposure limits recommended in the ICNIRP statement is capable of accomplishing the reduction in brain cancer risk that the ICNIRP statement implicitly claims for them.

The purpose of this letter is to make the public aware of my grave reservations about the wisdom of the recommended exposure limits contained in the ICNIRP statement, and to try to minimize the damage to the public health that seems likely to result from the ICNIRP's issuance of its statement on the health effects of use of hand-held radiotelephones, and from publication of this document in *Health Physics*.

I briefly summarize below the basis for my concern, in order to make the logic of my position apparent; then I discuss these points at further length.

1. There are two distinctly different types of health effect that can result from exposure to electromagnetic fields: *thermal* and *nonthermal* effects. These two types of health effect are produced by different mechanisms. The mechanism by which thermal effects are produced is understood: they arise from the generation of heat resulting from induced electric currents. Or, to put it another way, thermal health effects arise from the absorption of electromagnetic energy by biological tissues. The mechanism by which nonthermal effects are produced is not yet understood, but it is *not* the same mechanism as that by which thermal effects are produced.

2. Assuming cancer to be a health effect resulting from exposure to electromagnetic fields, it is a nonthermal health effect, not a thermal health effect.

3. Standards based on the SAR, as the recommended exposure limit in the ICNIRP statement is, impose an upper limit on the rate of absorption of electromagnetic energy by biological tissues; thus such standards have a sound scientific basis when they are employed to control a *thermal* hazard. However, no scientific basis exists to support an allegation that a standard based on an SAR can protect against a *nonthermal* hazard.

4. Because the hazard associated with the use of hand-held radiotelephones is a cancer hazard—brain cancer—and cancer is a *nonthermal* health effect, the SAR-based standard recommended by the ICNIRP as a means of reducing the hazard to health posed by the use of these devices lacks a sound scientific basis. The ICNIRP-recommended exposure limit will certainly improve protection against any *thermal* hazards that may be associated with the use of these devices—but because no thermal hazards to the users of these devices are in evidence at this time, the protection conferred by the standards recommended in the ICNIRP statement appears to be *quite unnecessary!*

5. Cancer being a nonthermal health hazard of electromagnetic field exposure, and the ICNIRP statement offering nothing except a standard appropriate for controlling a thermal hazard, the ICNIRP statement is completely lacking in any recommendation that could reasonably be expected to reduce any cancer hazard posed by the use of hand-held radiotelephones!

In summary, the ICNIRP is correct, in my judgment, to think that a cancer hazard may exist and that action is needed to reduce or eliminate this hazard to users of self-contained, hand-held cellular telephones. But the ICNIRP is making exposure recommendations that are *inappropriate for the cancer hazard against which protection is needed!*

Before I present support for my argument, let me address the feeling, shared by many, that an increased measure of protection *will* be provided by lowering current levels of exposure, and that for this reason, the ICNIRP statement is "a step in the right direction" even if it should later be learned that it did not go far enough. This logic rests on the assumption that, for *all* adverse health effects resulting from exposure to non-ionizing electromagnetic fields, the risk of harm or severity of injury is a monotonic increasing function of the strength of the electric and magnetic fields.

That this assumption is correct for the *thermal* health effects of exposure to non-ionizing electromagnetic radiation is well-known; it justifies the establishment of an *upper limit* on these field strengths (via the Poynting vector) to control thermal health hazards. But the available evidence (Morgan 1986) suggests that this assumption is *incorrect* for *nonthermal* health hazards!

Morgan discussed the electromagnetic fields that surround electric power lines; these are near fields, not far (radiation) fields. Furthermore, we can be confident that 50-60 Hz fields do *not* produce *thermal* health effects, so any health effects that may be associated with them must be nonthermal in character. Morgan commented that 'results are complicated by experimental evidence which suggests that if there should turn out to be adverse health impacts, stronger fields might not be "worse" than weaker fields' and he then pointed out that 'the scientific evidence ... does not even offer many suggestions about what we should do if we want to "play it safe," since unlike most chemical hazards, in this case we probably cannot assume that "if it's bad, more is worse."'

Presumably the nature of the relationship between electromagnetic field strength and any nonthermal health effect is likely to be similar at different frequencies. I have seen experimental data obtained at a U.S. government laboratory where the biological effect under study—which was not cancer, but a rapidly occurring bioeffect, the thermal or nonthermal character of which has been under dispute—was plotted against the microwave power density. These plotted points suggested a peaked curve, not unlike a resonance peak. If confirmed, such a relationship would imply the existence of some value of power density at which the hazard is maximal, with relative safety lying not only at much *lower* values of the power density, but also at much *higher* values! This is an illustration of the kind of unanticipated behavior that Morgan (1986) was referring to. Thus it is not impossible that the recommendations of the ICNIRP statement, if followed, might actually tend to *increase* the risk of brain cancer, since observable nonthermal health effects seem to be confined to fields of very *low* intensity!

Because of the very different dependences of thermal and nonthermal health effects on field intensity, it is *absolutely essential* that these two different health effects be assessed *independently* of each other! At this time, *no* scientific document—certainly not the World Health Organization document (UNEP/WHO/IRPA 1993)—does this!

I return now to the ICNIRP statement on hand-held radiotelephones, a document I have singled out for criticism because it addresses *exclusively* a nonthermal health hazard. Here is support for the specific points of my argument.

The existence of a thermal health hazard from exposure to non-ionizing radiation is very well accepted. The existence of a nonthermal health hazard from such exposure has been a matter of controversy, however. The scientific evidence in favor of the existence of nonthermal health effects—beneficial as well as detrimental—has grown over the decades. Indeed, a professional scientific society—the Bioelectromagnetics Society—was established about two decades ago to provide a forum for discussion of their exploration.

So it is probably accurate to say that nonthermal health effects are now widely—though not unanimously—acknowledged to exist. That nonthermal effects exist at the cellular level is certainly the conclusion of Grundler et al. (1992).

The fact that two distinct, different types of health effect can arise as a result of exposure of biological tissues to electromagnetic fields implies that there are two distinct, different mechanisms by which electromagnetic fields can interact with biological tissues. After all, if there were only *one* mechanism of interaction, it would be impossible for there to be more than a *single* type of health effect! Given the evidence that there are *two different* types of health effect, there must consequently be *two different* mechanisms of interaction. About the mechanism by which *nonthermal* health effects are produced, we know only that it does *not* result from the absorption of electromagnetic energy, because this is the mechanism which produces thermal health effects.

Assuming that cancer is indeed a genuine health effect of exposure to electromagnetic fields, and not an artifact wrongly attributed to electromagnetic field exposure, cancer *must* be either a thermal or a nonthermal effect, because these are the *only* types of health effect known to occur as a consequence of exposure to electromagnetic fields. A simple argument shows that cancer *cannot* be a thermal health effect.

The elevation of tissue temperature that accompanies thermal health effects is employed therapeutically to *kill* cancer cells (which are more susceptible to elevated temperatures than are normal cells). Cancer, on the other hand, is characterized by the uncontrolled *growth* of tissue.

That which encourages growth is necessarily different from that which kills. Since severe thermal effects are lethal to all cells, the carcinogenic property of electromagnetic field exposure cannot possibly be a thermal effect; therefore carcinogenicity must be a *nonthermal* health effect of electromagnetic field exposure.

The ICNIRP statement clearly states that the limits it recommends are based on the SAR. This means that the ICNIRP-recommended exposure limits are based on tissue absorption of electromagnetic energy, which is a *thermal* mechanism. Since cancer does *not* arise as a result of a *thermal* mechanism, this means that an exposure limit based on controlling the thermal mechanism must necessarily be *irrelevant* to the control of the carcinogenic properties of exposure to electromagnetic fields!

A standard that is not relevant to its purpose is an ineffectual standard. There can be no purpose for the exposure limits recommended in the ICNIRP statement as applying to hand-held radiotelephones other than to reduce the risk of cancer, because there has been no adverse health effect other than cancer associated with the use of these devices.

As I have shown here, the SAR-based exposure limits recommended by the ICNIRP cannot possibly be effective against a cancer hazard arising from exposure to electromagnetic fields. The ICNIRP statement is therefore *perpetrating a fraud upon the public!*

There are some fundamental differences between the way a scientific committee, such as the ICNIRP, operates and what an industrial hygienist does. Scientific committees usually have a very specific charge and look at a limited data set—typically, papers published in the peer-reviewed scientific literature. Furthermore, they tend to demand overwhelming scientific proof of hazard before they are willing to conclude that a hazard to health exists—and this usually cannot be supplied until a hazardous situation has existed for a long time, producing a considerable amount of disease!

Industrial hygienists who work within industry find that they must offer advice to corporate management when there simply are not enough data to enable them to be sure what the situation is! A senior, experienced industrial hygienist is expected to employ "professional judgment" in such a situation; this entails consideration of all available knowledge from whatever sources the industrial hygienist deems reliable. In the final analysis, it is a judgment call (as most business decisions are, being based upon incomplete information). If company management accepts the industrial hygiene recommendation, it may well be "betting the company" on the industrial hygienist's judgment! Since the industrial hygienist is a professional in disease prevention, there has been a failure if a firm follows the recommendations of its industrial hygienist, and disease nevertheless develops! So industrial hygienists who value their reputations tend to err on the side of safety.

Thus there is a difference in emphasis between the scientific committee and the industrial hygienist. The former wants to make sure that it does not falsely declare the existence of a hazard where there is none; the latter wants to make sure that a situation is not declared safe, if a hazard to health really exists.

For those who desire *effective* guidance in reducing or eliminating the brain cancer risk that I believe to be associated with cellular telephone use, I recommend my own document (Lundquist 1996), which is based on a thorough review of the available evidence and a comprehensive understanding of the characteristics of electromagnetic fields in the vicinity of transmitters. My document does not directly recommend an exposure limit, though indirectly it recommends the only exposure limit that everyone can agree at present would ensure an absence of risk of brain cancer attributable to the electromagnetic fields around a hand-held radiotelephone: a limit of *zero!*

In this context, an exposure limit of zero implies that the hand-held radiotelephone is generating *no electromagnetic field at all!* Or, to put it another way, such a radiotelephone is being used only as a receiver, not as a transmitter.

Very briefly, my document distinguishes between the various types of electromagnetic field in the vicinity of a radio-frequency transmitter, and shows that the cancer hazard associated with cellular telephone use—indeed, with proximity to *any* radio-frequency source—seems to be associated with exposure to the *near field* of the transmitter. This is a new idea which is not to be found in the literature reviewed by the ICNIRP.

This concept—that the cancer hazard of radio-frequency devices is associated with long-term exposure to the *near field* of a transmitter—implies that there is an elevated cancer risk *only* when the device is transmitting, *not* when it is receiving. When the device is being used as a receiver, the user is in the far field of a remote transmitter, and so experiences *no near field exposure at all!* So using a hand-held radiotelephone only to receive messages, not to send them, is one way to eliminate any brain cancer hazard that may be associated with the use of these devices. Other ways to reduce this hazard are also possible; they are discussed in Lundquist (1996).

Let me summarize the points made in this letter. The ICNIRP statement is both unscientific and deceptive in that it confuses two distinctly different kinds of health hazards. It wrongly implies that measures taken to protect against one type of health hazard—the thermal hazard—are likely to be effective against *both* types of health hazard. Its recommendations may even tend to *increase* the brain cancer risk to users of hand-held radiotelephones!

It is my professional judgment that anyone who relies upon the voluntary consensus exposure limits recommended in the ICNIRP statement, in the expectation of thereby reducing the risk of brain cancer in the population using cellular telephones, should prepare to be disappointed! Reliance upon the exposure limits recommended by the ICNIRP can be expected to produce *no* reduction in the brain cancer risk to which the population of cellular telephone users is currently exposed!

In view of the mischief to the public health that its published statement seems likely to cause, I call upon the ICNIRP either to *withdraw* its 1996 statement on health issues related to the use of hand-held radiotelephones, or else to *modify* this document in a manner that is responsive to my criticisms of it and that upholds the spirit of the ancient injunction to the physician: "Above all, *do no harm!*"

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APPENDIX C

A GUIDE TO THE PREVENTION OF DISEASES ARISING FROM EXPOSURE TO RADIO-FREQUENCY RADIATION

Certain wireless devices pose a high risk of cancer or other serious disease when used in the manner intended by the manufacturer. The document in the following pages was written:

- to warn the public of this hazard;
- to show how much evidence there is of such a hazard; and
- to provide guidance to the public in protecting itself from this hazard.

Basically, the public is taught to ***stay well out of the near field of radio-frequency transmitters!***

Cellular Telephones and Cellular Towers:

GUIDELINES FOR CANCER PREVENTION

by

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N.B.: This is directed toward an audience located in the United States of America. The general principles, of course, are valid everywhere in the world.

Introduction

Although cellular telephones are convenient, popular, and in widespread use, questions have been raised about possible hazards to the health of the people who use them, such as brain cancer. Likewise, there are concerns for the people who live or work in the vicinity of the tower-mounted transmitters that serve each geographic "cell" in a metropolitan area. Since the authorities do not at present recognize the existence of a health hazard from either piece of equipment, it is up to the public to protect itself--or it ***was***, prior to passage of the Telecommunications Act of 1996.

Passage of this Act has deprived the public of its traditional right to take action to protect itself by means of the political process at the local level. Nevertheless, the following two sections provide basic information for citizens who want answers to questions regarding a potential cancer hazard from both cellular telephones and cellular towers.

The hazard in both instances is associated with the electromagnetic field around the transmitter during transmission. The best method of protection is to keep an adequate distance between all human body parts and each transmitter during transmission.

Cellular Telephones: Is There a Brain Cancer Hazard?

With respect to cellular telephones designed so that the transmitter is in the handset, there certainly seems to be a brain cancer hazard associated with their prolonged use. When I last checked, eight lawsuits had been filed on behalf of heavy users of cellular telephones who had developed brain cancer behind the ear on the side of the head where the cellular telephone was normally positioned while it was in use.

Eight cases of suspicious brain cancer, by themselves, hardly constitute conclusive evidence that cellular telephones cause brain cancer. On the other hand, this is strongly suggestive of a cancer-causing relationship between the cellular phone transmitter and the brain tissue of the user.

These eight lawsuits don't exist in a vacuum, though. There is supporting evidence from up and down the electromagnetic spectrum that exposure of human tissue to an appropriately low-power ***near field*** of a radio-frequency source will--eventually--give rise to cancer in the exposed tissue. Tissues of the nervous system seem to be especially susceptible, as has long been known.

It should be stressed that cellular telephones are low-power devices. They were designed to comply with the one existing standard for non-ionizing radiation exposure: ANSI C95.1. This standard was originally developed to protect mammals against a ***thermal*** hazard; that is, it was designed to prevent mammalian tissues from being ***cooked***! It accomplishes this by imposing an upper limit on the magnitude of the areal power flux, often called the ***power density***. This parameter is measured by the ***Poynting vector*** of electromagnetic field theory.

The ANSI standard has accomplished its intended purpose, so far as cellular telephone users are concerned: their brain tissue is ***not*** being cooked! Instead, it seems to be developing cancer under conditions of ***long-term exposure to the near field*** of these low-power transmitters. (The near field usually is considered to lie within a volume having a radius of $\lambda/2\pi$, λ being the wavelength of the signal.)

The frequencies used by cellular (and PCS) telephones in the USA range up to 900 MHz. What is the evidence from elsewhere in the electromagnetic spectrum?

In earlier articles (**Nexus**, Nov. 1995; **Network News**, *Holiday Issue 1994*), I discussed the historical rise in the incidence of childhood brain cancer suggestive of an urban source that became active in the 1920s, which is when commercial radio broadcasting began in the USA. The frequencies employed were in the kilo- and megahertz range, which are mostly below those now being used for cellular telephones. This evidence is suggestive of an association between childhood brain cancer and the fields around amplitude-modulated radio transmitters, but it is far from conclusive.

On the other hand, it is quite consistent with the concept that prolonged exposure to the near field of a radio-frequency source is carcinogenic, because these wavelengths can be as much as a mile long, which means that people living anywhere within 0.15 miles of such a transmitter would be living within its traditionally defined near field. So the evidence from lower radio frequencies is consistent with the concept that the major carcinogenic hazard from a transmitter resides within its near field.

At gigahertz frequencies, though, there is again evidence of an association between cancer and exposure to the near field of a low-power source of microwave radiation. I refer to the numerous cases of cancer that have been reported in law enforcement officers who, during their employment, used the earliest design of traffic radar gun--a device that can measure the speed of a moving vehicle. These are also low-power devices, designed to comply with the ANSI standard: ANSI C95.1.

The earliest traffic radar guns emitted a continuous beam for as long as they were turned on. Because officers wanted to conceal the beam when they were not actually making a measurement of vehicle speed, they tried to "hide" it in various ways, each